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derstand him rightly) supplementary to that of sight. True it seems in many cases as though insects deprived of their antennæ are somewhat blind; but in vastly more instances they do not seem so. Take, for example, almost any beetle one may pick up. Cut off the antennæ and let them run, and we cannot get them to act in any way not as before. Whatever it be it is in a very different manner connected with the life of different insects. In many instances the deprivation of them seems almost fatal; in others again it is scarcely noticed. Cut them off from a sleeping roach and it will barely awake. Take your scissors and snip them from the gray "stinck bug" as it walks over your window sill or on your door step, and it will stop short where it is and sit still for hours in one place. All experiments of this kind are easily performed, and I hope that many who have even a very few moments to spare, will pay some attention to this part of science, so late in being fully investigated. If so, one object, at least, of this paper will be accomplished.

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# ON THE POSITION OF THE COMPOSITÆ AND ORCHIDEÆ IN THE NATURAL SYSTEM.

BY JOSEPH F. JAMES.

THE various authors who have, at different times, written on systematic botany, have had different schemes for a natural arrangement of the orders of plants. Some have placed one order at the head of the system, some another. Hardly two seem to agree as to the ones which should follow in a natural sequence. The large majority of writers, if indeed not all, have considered the Polypetalous division of the Dicotyledons the most highly developed, and have placed the Gamopetalæ in the second, and the Apetalæ in the third class. Ever since the time of DeCandolle, in 1813, down to Bentham and Hooker, our latest authorities, the Ranunculaceæ have generally been placed at the head of the flowering plants. It is the intention, in the present paper, to show reasons why this should not be so, and to suggest another and very different arrangement of the orders.

It would be well at the outset to remark that no system of botany is to be regarded as unmodifiable. All opinions, all ideas, are liable to change, and the fact cannot be better stated than was expressed by Lindley, in 1845, in the preface to his Vegetable

Kingdom (p. XI). He says: "Consistency is but another word for obstinacy. All things are undergoing incessant change. Every science is in a state of progression, and of all others the science of observation most so. Since 1836 the views of the author have, of course, been altered in some respects, although they have experienced but little modification in others. This is inevitable in such a science as that of systematic botany, where the discovery of a few new facts or half a dozen fresh genera may instantly change the point of view from which a given object is observed. The author cannot regard perseverance in error commendable for the sake of what is idly called consistency; he would rather see false views corrected as the belief of their error arises. * * * All that we can do is to throw our pebbles upon the heap which shall hereafter, when they shall have sufficiently accumulated, become the landmark of systematic botany."

With our modern ideas and knowledge of botany, we have pretty nearly all come to the conclusion that any strictly lineal arrangement of plants is out of the question. Nor is the idea altogether a modern one, for we find many old writers expressing the same opinion. Says Lindley, in 1845: "It is impossible, from the nature of things, that any arrangement should exist which shall represent the natural relations of plants in a consecutive series. It is generally admitted by those who have turned their attention to a consideration of the manner in which organized beings are related to each other, that each species is allied to others in different degrees, and that such relationship is best expressed by rays (called affinities) proceeding from a given center (the species)." And Brongniart, in 1843, had also insisted on the impracticability of a lineal arrangement of plants.

Although it is universally admitted, however, that the Monocotyledons are of a lower type than the Dicotyledons, yet he would be rash, indeed, who would say that the highest of the former division should stand lower than the lowest of the latter. That, for instance, the Orchideæ should be below the Chenopodiaceæ or the Euphorbiaceæ. So that the only way in which we can with justice and method arrange plants, is on several parallel lines.

As evolutionists, botanists must acknowledge that all plants, Monocotyledons or Dicotyledons, have sprung from one source, but they must have diverged at a very early period, and now represent two of the largest branches of the great botanical tree. So that if we would find the plants of the two classes which are most closely allied, it must be with the lowest forms of each, rather than with the lowest forms of the one and the highest forms of the other. Leaving now for the present the consideration of the Monocotyledons as lower in organization and structure, let us turn to the Dicotyledons and see what disposition can be made of the various orders, and which ones deserve to take the highest rank in the scale.

The Polypetalæ, Gamopetalæ and Apetalæ are the three classes into which the Dicotyledons have been generally divided, a division which, though in many ways artificial, is yet natural enough to serve our present purpose. Now there are several things which must be taken into consideration as establishing a high rank in the vegetable kingdom. Every one knows that the office for which every plant exists in nature, its chief function, is the production of seed, and the manner in which this is performed may be regarded as indicating, to a great degree, the relative rank of a plant in the scheme. This being granted, it can hardly be denied that those plants which produce the most seed with the least expenditure of material, and have at the same time the most perfect provisions for cross-fertilization, and are also among the most dominant families, should take a very high, if not the highest rank in the system.

Now of all plants in the world, the Compositæ take the lead in point of numbers and importance. Roughly estimated they number from ten to twelve thousand, and thus form about one-tenth of the whole number of flowering plants known. In some countries they constitute one-sixth of the whole flora, so that if a dominant type or family is a mark of high rank, where else than at the head should we place the Compositæ? That it should stand high would be immediately inferred from its very dominance. For if not of a highly specialized type it would never have been able to hold its own and increase to such an enormous extent, and occupy so large a space in the flora of the world. We recognize man as the highest type of mammal, and he too is the most dominant and the most widespread. Another argument for the high rank of the Compositæ, is the fact that they have been developed from the first most profusely in the tropics. There where the climate has been the most equable, most constantly the same, we find the metropolis of the order. There they are the most abundant. So, too, was man first developed in the tropics, or at least in countries with a tropical or semi-tropical climate.

But what argument, it might be asked, can be adduced to justify the statement that the Compositæ were first developed in the tropical regions? Principally because the season of flowering of nearly the whole family is, in the temperate regions, in summer or in fall. The further north the place of origin of a plant is, the earlier will it bloom in countries situated towards the equator. Nearly all the members, for instance, of the Ranunculaceæ which have a northern distribution, bloom very early in the spring. So those species of Compositæ with a northern extension bloom first, and only those, while the more southern forms come later into bloom in their northern habitats. So that we would seem justified in concluding that as so many of our Compositæ do not bloom with us in the temperate regions until late in summer or in autumn, that they have originated in the countries close to or on the equator.

Let us now look at the flowers. We find that what looks to a superficial observer like a single flower, and is the compound flower of the old botanists, is really a cluster, a head of perfect flowers set on a common receptacle. The central florets in the majority of the genera are all perfect and produce seed. In the Tubulifloræ, comprising the larger part of the family, we find many genera with the outer flowers modified for a special purpose. While the disk florets are tubular, with five lobes to the corolla, the outer ones often become ligulate; the lower part only remaining as a tube, and the upper portion spread out into a broad ray with from two to five teeth, representing the original lobes of the corolla. The ray flowers sometimes produce seed; oftener they are sterile, and their only purpose is to render the flower more conspicuous to insect visitors. Thus we find here a company of flowers sacrificing some of their number to benefit the rest. Further, again, we find the corollas destitute of calyxes, these being reduced to scales, pappus or bristles. Also we find a definite number of stamens, five, all perfect, all enclosed in the corolla tube and fastened into a ring, and shedding their pollen into the tube. Again, that the flowers are all proterandrous, and though the anthers and pistil are both present in each flower, the arrangement is such as to prevent self-fertilization, unless very rarely. For as the pistil grows, it pushes the pollen out of the tube, and on reaching the outside, expands its lobes ready for fertilization, but not until then; and when, too, it is most likely to receive pollen from a neighboring plant or flower-head.

Surely then we have here, in the Compositæ, a very high type of flower. In the first place a very great saving of material is effected by the union of the separate petals, such as we find in the Polypetalæ, into one piece. Secondly, in the reduction of the calyx of the ordinary flower to pappus, bristles or scales, which often also answer as means of dissemination, we have another decided saving of material. Thirdly, the stamens being reduced to a small number, and being so arranged as to shed their pollen where it will not be lost, and is yet ready for use. Fourthly, the pistil being mature only after the pollen falls, is thus assured of a cross in fertilization, to the manifest benefit of the seed; and fifthly, the flowers being set upon a common receptacle, are more noticeable to insects, are more compact, more easily visited, and are more likely to produce a larger number of seed. Each one of these seeds, too, is separate, and that may be regarded as another mark of a high rank. So that taking all things together, I would place the large family Compositæ at the head of the Gamopetalæ, and as the head of that class, at the head of the whole vegetable kingdom.

It will be seen now that I regard the Gamopetalæ as of a more highly organized and specialized type than the Polypetalæ. For it seems to me that by the union of the separate parts of the corolla, and of the calyx into one piece, so much material has been saved to the plant, so many idle expenditures have been cut off, and the work is performed by fewer members and in a more perfect manner.

It is a difficult matter to say what order shall be regarded as standing next to the Compositæ in rank. The family has few near relatives, and is isolated in many respects from nearly all the other orders. But considering the Compositæ as the head of one line of development, it would seem that in the Labiatæ we have another order which is also, in many respects, highly specialized, and ought to be regarded as at the head of the next highest line in the Gamopetalæ. The family is as remarkable as the Compositæ in one way, as it stands nearly alone in its peculiarities, and the genera are so much alike in general characteristics that LaMaout and Decaisne have termed it a "monotypic family." For to know one Labiate is to know all of them. The genera are separated on small characters, obscure and difficult to observe. But the high rank of the family is indicated in the peculiarly modified corolla, bi-labiate, with elaborate arrangements in many genera for cross-fertilization, and in the ovary. This last is so distinct from all other families, with a solitary exception, that it might be used as characterizing this family exclusively. The only other order, Boragineæ, which has the same sort of a deeply four-parted ovary, differs markedly in having regular flowers.

In placing Labiatæ next to Compositæ in rank, it should not be understood that it is done with the idea that one is descended from, or is a modified descendant of the other, but simply that in the Labiatæ we find, next to the Compositæ, the most highly organized family of plants. Their predominance in Southern Europe, where they have been subjected for so many centuries to such a fierce struggle for existence, may account in a measure for their peculiar development, and their ability to hold their own in the world. Their aggressive nature, too, is well shown in the fact, that out of fifty genera known to North America, nineteen of them, or more than one-third, have introduced species.

Closely allied to the Labiatæ, on the one hand, is the Verbenaceæ, and on the other the Boragineæ. It is, of course, impossible in this paper to indicate the position of all or even very many of the natural orders. Scrophularineæ should, however, stand somewhere near Boragineæ.

Leaving now the Gamopetalæ, let us turn to the Polypetalæ and examine some of the orders. Here again I would change many things, and first of all dethrone Ranunculaceæ. They are by no means entitled to the first place in any system. But it seems to me that here the Leguminosæ, as most specialized and organized in many respects, should take the first rank. The flowers of many of the Ranunculaceæ are of the simplest type, with five petals, indefinite stamens and many pistils; while in the Leguminosæ we find many very profoundly modified flowers, with ten stamens and the peculiar fruit known as a legume. The modifications in the corolla have, of course, reference to cross-fertilization. Many of the species cannot produce any seed with-out the aid of insects, and the contrivances serving the same end are many and various. Those with Papilionaceous flowers we may consider as specially modified, and these include nearly three-fourths of the genera and a still larger proportion of the species. Laying special stress upon the seeds and means for cross-fertilization here, as we have before, we see good reason for calling the Leguminosæ highly organized plants. The leguminous fruit and the papilionaceous flowers, are two things found in no other family, and these two, or either one, will tell a legume as easily as the compact head of flowers will point out one of the Compositæ.

While the Leguminosæ are entitled to the highest rank in the Polypetalæ, the Compositæ hold the highest place of all, for the former fall below the latter because of the separation of the petals, the almost universal prevalence of a calyx, so profoundly modified in the Compositæ, the increased number of stamens, the smaller number of seeds produced, and their production in a pod instead of separately.

Closely allied to the Leguminosæ stand the Rosaceæ, but not so highly specialized, having simpler flowers, more numerous stamens and other characters. Allied to both of these is the order Saxifrageæ, and to it the Ranunculaceæ, and to the latter the Umbelliferæ. In numerical strength and in distribution too, do we find these several families arranged in much the same order. Leguminosæ with 6500 species, Rosaceæ with 1000, Umbellifera with 1300, and Ranunculaceæ with 540. In distribution the Leguminosæ have the widest range and are especially abundant in the tropics, the Rosaceæ come next, the Umbelliferæ third, being rare in the lowlands of the tropics, and the Ranunculaceæ are last, largely confined to temperate and arctic regions.

Referring now to the Monocotyledons, we find that of all the orders the Orchideæ is the largest, there being known at present between 4500 and 5000 species. The order thus stands third from Compositæ. We find the species of orchids to have a very local distribution, but the family itself is very widely scattered. Their metropolis, as with the Compositæ, is in the tropics, especially in America, and we find a large proportion of them to be epiphytes. From the fact of the species having such a local distribution, it will probably be found that when the tropics have been thoroughly explored, that the number of species will be materially increased. Wallace (Tropical Nature, p. 50) says: "More than thirty years ago the number of known orchids was estimated by Dr. Lindley at 3000 species, and it is not improbable that they may be now nearly doubled. [We have seen this to be the case.] But whatever may be the numbers of the collected or described orchids, those that still remain to be discovered must be enormous. Unlike ferns the species have a very limited range, and it would require the systematic work of a good botanical collector during several years, to exhaust any productive district—say such an island as Java—of its orchids. It is not, therefore, at all improbable that this remarkable group may ultimately prove to be the most numerous of all the families of flowering plants."

The Orchideæ differ in a marked manner from all other plants, standing almost isolated. In no other order do we find such marvelous contrivances to bring about cross-fertilization. In many and in fact most instances the visits of insects are absolutely necessary in order to enable the plants to produce any seeds, and we could not find such a state of affairs unless the order was a highly developed one. Many of the species have been so profoundly modified, that only one kind of insect can be of use. Some of the gigantic orchids of Madagascar are absolutely dependent upon large moths which are found in the same island. In other species the sexes are separated, or there are two or three different kinds of flowers of the same species. One bears the pollen, another the stigma, and a third is provided with both. The peculiar modification which the pollen has undergone, the grains tied together by elastic threads, and the pollinia enclosed in anther cells, is unknown to any other family except the Asclepiadeæ, a family in no way connected with the Orchideæ. In point of fact, everything about the whole order shows it to be nearly equal in rank, in point of structure, with the other heads pointed out, viz., Compositæ and Leguminosæ. It would be folly to arrange any lineal scheme with Compositæ first, Leguminosæ second, and Orchideæ third. No one would dream of such a thing; but it is only just to say that each of these orders holds the highest place in each class it occupies.

In the scheme here given (see chart) I have arranged the orders of the Monocotyledons given by Bentham and Hooker. Placing Orchideæ at the head, we have affinities with Liliaceæ through Burmanniaceæ, Hydrocharideæ, Naiadaceæ and Pontederiaceæ;

and the Liliaceæ occupy the head of an alliance of which Juncaceæ may be considered the center. This alliance will include Amaryllideæ and Irideæ, and connect through Flagellarieæ with the Palmæ, which itself stands at the head of the Aroidal alliance, with Lemnaceæ in the lowest rank. On the other hand, Gramineæ and the other glumaceous plants are indirectly connected with Juncaceæ, and are at the head of the glumaceous alliance. Though perhaps incorrect in some of the details, I think that in placing Orchideæ, Liliaceæ, Palmæ and Gramineæ at the head of the four lines upon which the Monocotyledons have developed, that I am not very far from a natural scheme.

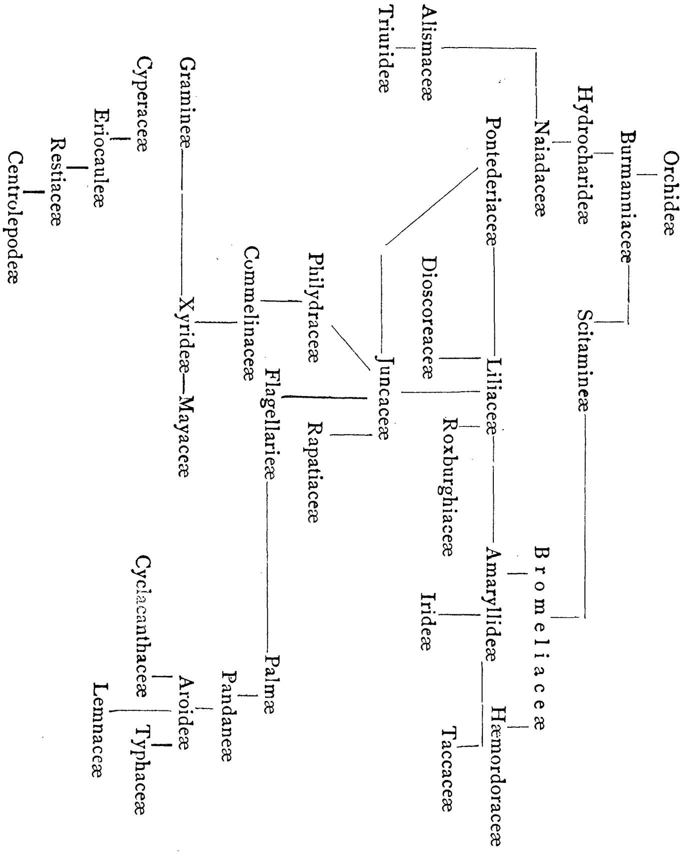

CHART OF THE MONOCOTYLEDONS.

It will very readily be seen, now, how utterly impracticable it is to arrange plants lineally. How could it possibly be done? How could we, by taking the orders in the order of their highest development, Orchideæ, Liliaceæ, Palmæ and Gramineæ, say that one was descended from or even directly connected with the others? It would be a violation of all principles of classification, and a libel on common sense. But when we take each order and show how, through this genus or that one, it is directly or remotely connected with some other one, then we feel a little confidence in saying we are approaching a natural classification. None of our systems can be entirely natural at present. We do not know, as yet, the characters and affinities of all the plants in the world, and until we do know that we cannot hope for anything but an approximation towards the correct idea of a perfectly natural arrangement of plants.

[*Note.*—This article was first read at a meeting of the Cincinnati Society of Natural History, and the first portion of it, viz., that relating to the Compositæ, was afterwards read at the Minneapolis meeting of the Am. Assoc. for the Adv. of Science.]

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# ON THE HABITS OF CERTAIN SUNFISH.

BY C. C. ABBOTT, M.D.

ALTHOUGH the two small centrarchoids, *Mesogonistius chætodon*, or banded sunfish, and *Enneacanthus simulans*, or spotted sunfish, have been long known to ichthyologists, almost nothing has been recorded of their habits.

In those of our shallow, sluggish waters, which have an indefinitely deep, muddy bottom, and harbor a rank growth of aquatic vegetation, the handsome, silvery, black-banded sunfish is a common species. In such localities, where often the weeds grow so luxuriantly that a scoop-net cannot be drawn, I have found that hundreds of these fishes were passing what I think must be a most monotonous existence. In some places locomotion must be rather a scramble among the water weeds, than a comfortable swim. Still, these spots have their advantages, for among these plants are to be found myriads of insect larvæ and other small fry that constitute a never-failing supply of food.

As a fish for the aquarium the banded sunfishes are deservedly popular, and indeed, they are better known as dwellers in such narrow quarters than as a prominent species in the fauna of the Lower Delaware valley. I believe they are not found above tide water at all. I have frequently shown these fish to old fishermen